

Exploration of Heise Natural-Flow Indices

ESHMC Meeting
8-9 March 2007

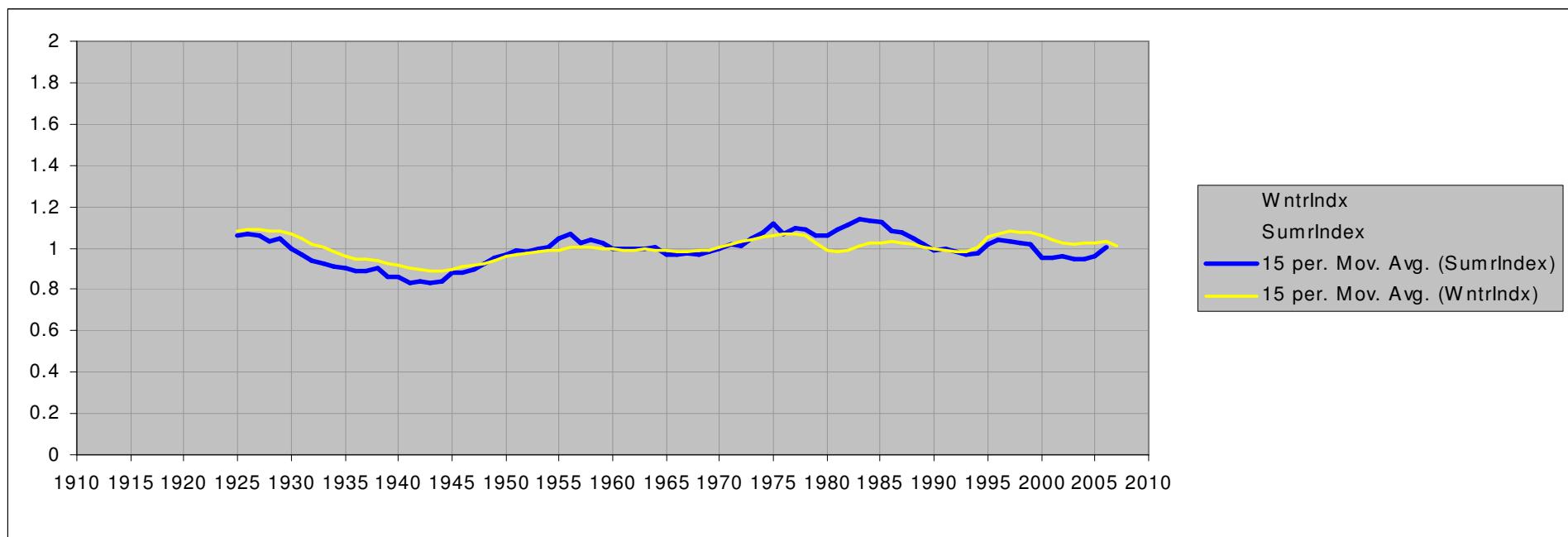
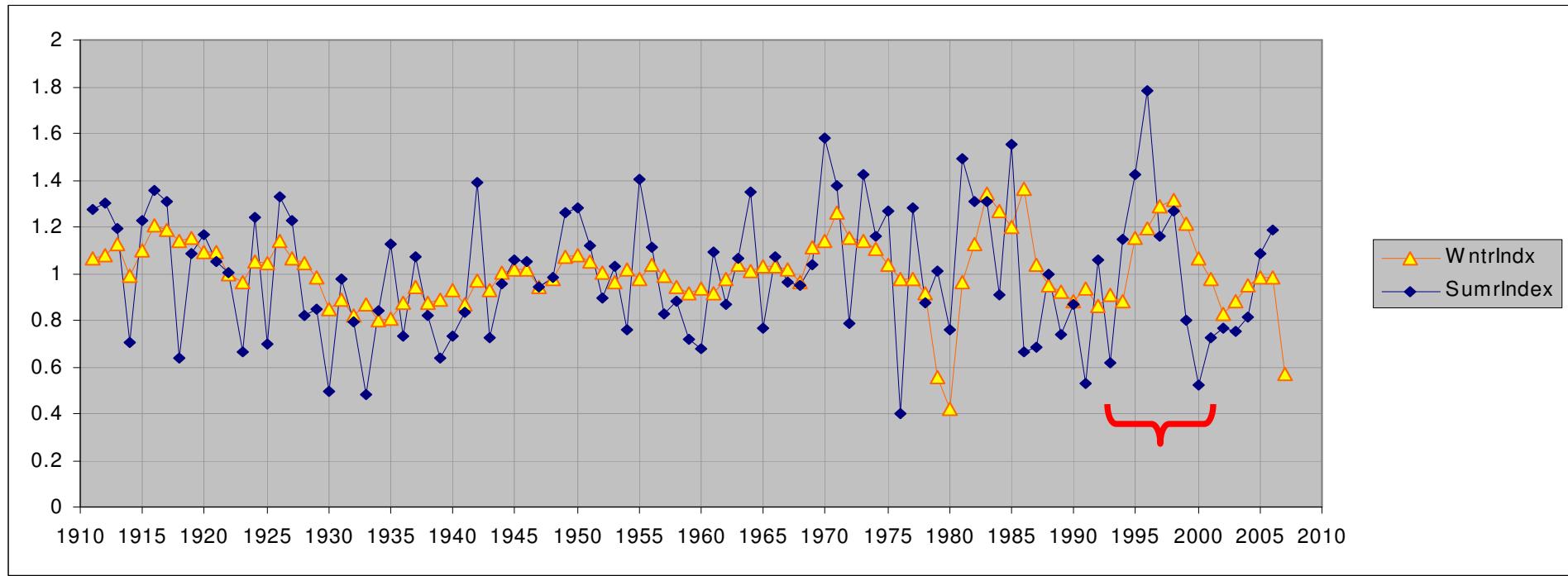
B. Contor

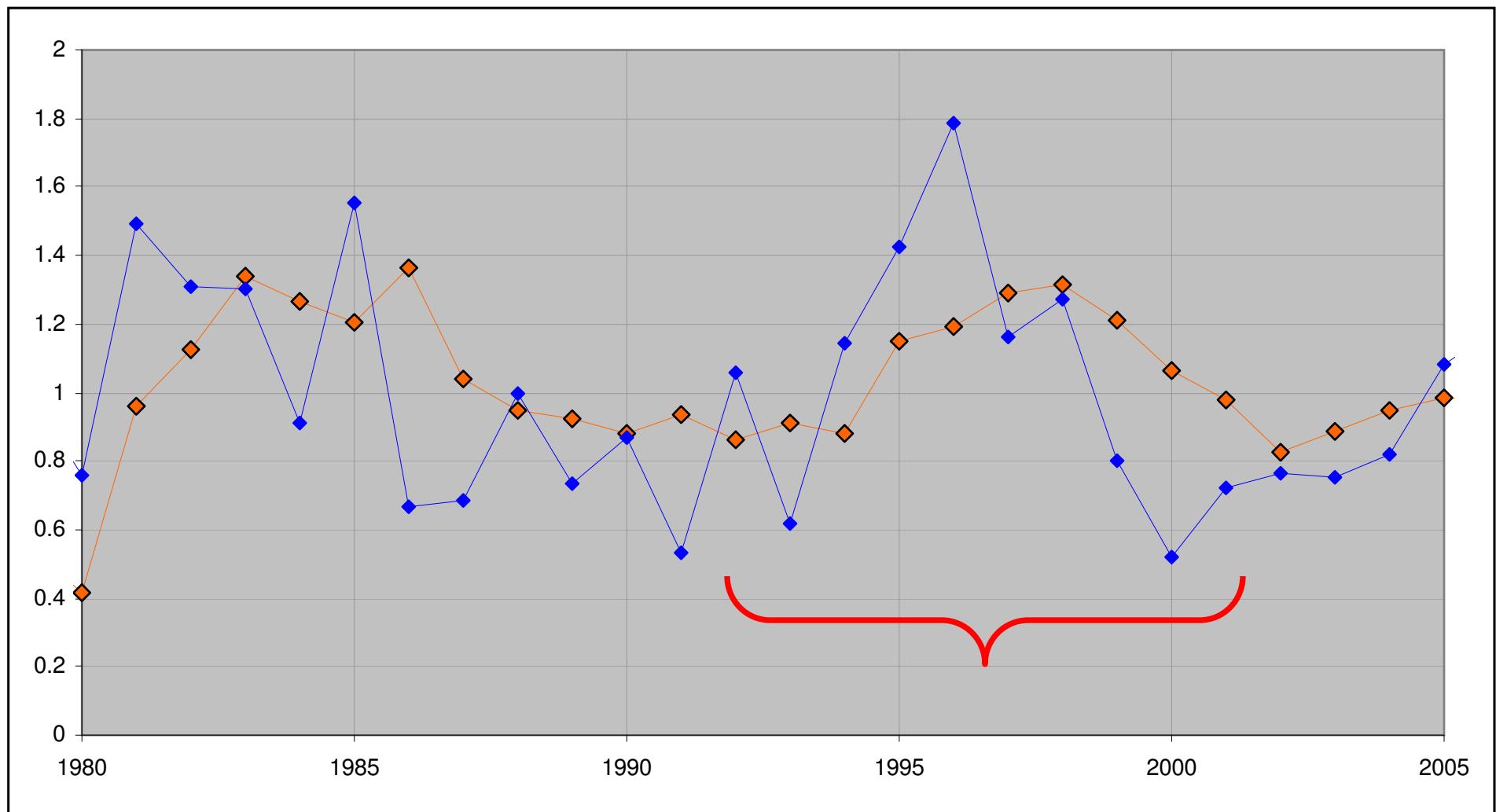
Two Indices

- Summer Index: Natural flow April – October *for the model year*
- Winter Index: Natural flow November – March *preceding the model year*

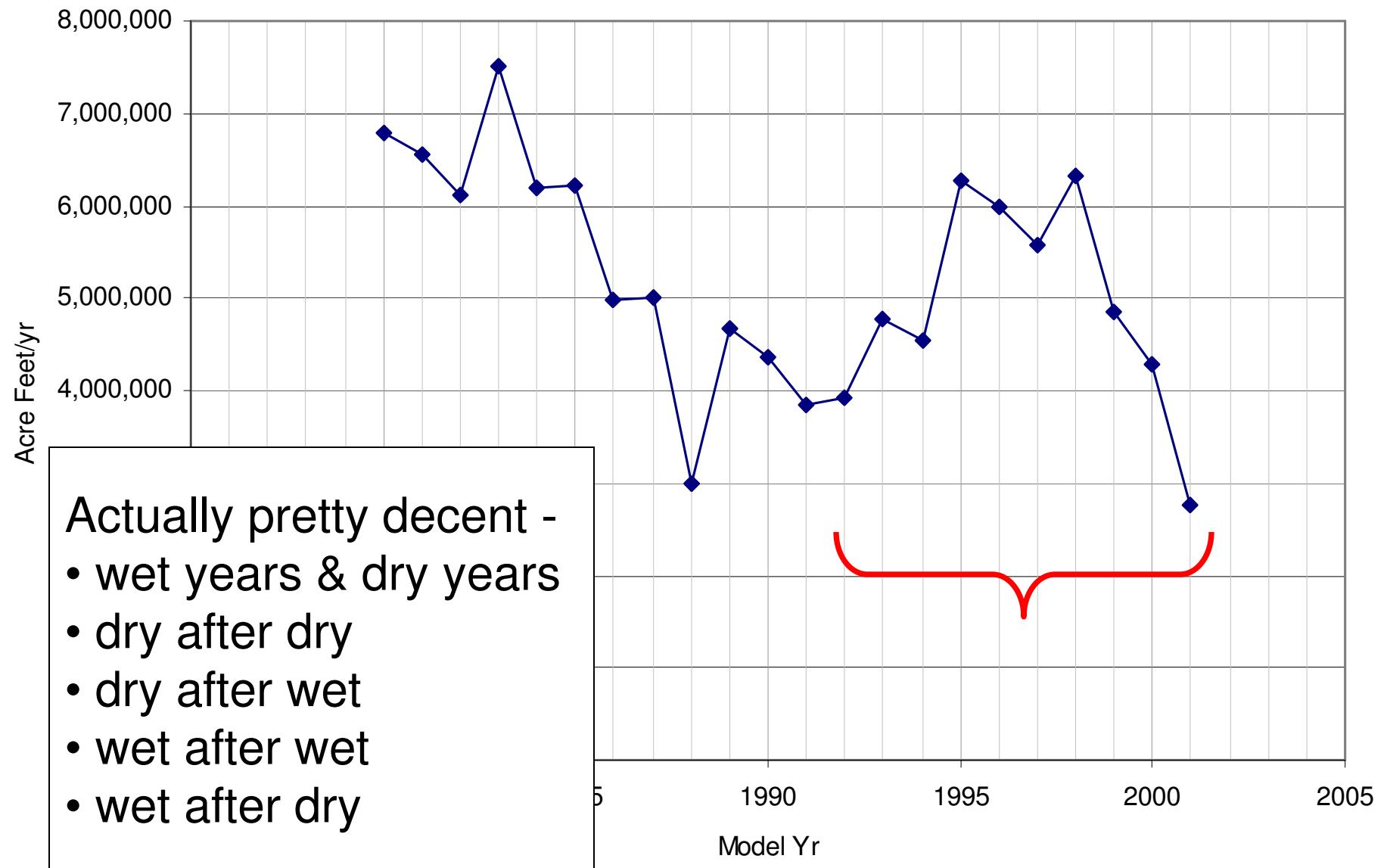
$$\text{Index} = \frac{\text{(current yr)}}{\text{(avg 1911 – 2006)}}$$

- Data from USBOR





Calibration Well Term Summary



Nine “Groups” Selected From Candidate Pool

- Five manual selections
- Selection based on winter-time index
- Selection based on summer-time index
- Summer selection + winter selection
- Excel Solver

Manual Groups

	1996.5	1.08504	1.050683
	Set 1	Wntr	Sumr
1	1992	0.862402	1.060596
2	1993	0.91041	0.615068
3	1994	0.881954	1.146259
4	1995	1.149788	1.425791
5	1996	1.192067	1.786185
6	1997	1.289401	1.160216
7	1998	1.312693	1.269855
8	1999	1.210302	0.800194
9	2000	1.064971	0.519666
10	2001	0.976409	0.722998

	1996.091	0.997188	1.000601
	Set 2	Wntr	Sumr
1	1992	0.862402	1.060596
2	1992	0.862402	1.060596
3	1993	0.91041	0.615068
4	1994	0.881954	1.146259
5	1994	0.881954	1.146259
6	1995	1.149788	1.425791
7	1996	1.192067	1.786185
8	1999	1.210302	0.800194
9	2000	1.064971	0.519666
10	2001	0.976409	0.722998
11	2001	0.976409	0.722998

	1997.667	0.995628	1.007394
	Set 3	Wntr	Sumr
1	1994	0.881954	1.146259
2	1994	0.881954	1.146259
3	1996	1.192067	1.786185
4	2000	1.064971	0.519666
5	2001	0.976409	0.722998
6	2001	0.976409	0.722998

	1996.208	1.01335	0.98826
	Set 4	Wntr	Sumr
1	1992	0.862402	1.060596
2	1992	0.862402	1.060596
3	1992	0.862402	1.060596
4	1992	0.862402	1.060596
5	1993	0.91041	0.615068
6	1993	0.91041	0.615068
7	1993	0.91041	0.615068
8	1994	0.881954	1.146259
9	1994	0.881954	1.146259
10	1994	0.881954	1.146259
11	1994	0.881954	1.146259
12	1994	0.881954	1.146259
13	1995	1.149788	1.425791
14	1996	1.192067	1.786185
15	1996	1.192067	1.786185
16	1997	1.289401	1.160216
17	1998	1.312693	1.269855
18	1999	1.210302	0.800194
19	1999	1.210302	0.800194
20	2000	1.064971	0.519666
21	2000	1.064971	0.519666
22	2001	0.976409	0.722998
23	2001	0.976409	0.722998
24	2001	0.976409	0.722998
25	2001	0.976409	0.722998

	1996.643	1.032302	0.996839
	Set 5	Wntr	Sumr
1	1993	0.91041	0.615068
2	1993	0.91041	0.615068
3	1994	0.881954	1.146259
4	1994	0.881954	1.146259
5	1994	0.881954	1.146259
6	1995	1.149788	1.425791
7	1995	1.149788	1.425791
8	1996	1.192067	1.786185
9	1997	1.289401	1.160216
10	1999	1.210302	0.800194
11	2000	1.064971	0.519666
12	2001	0.976409	0.722998
13	2001	0.976409	0.722998
14	2001	0.976409	0.722998

Groups Based on Historical Series

Yr	Sumrlndx	Wntrlndx
1992	1.061	0.862
		0.872
1994	1.146	0.882
		0.896
1993	0.615	0.910
		0.943
2001	0.723	0.976
		1.021
2000	0.520	1.065
		1.107
1995	1.426	1.150
		1.171
1996	1.786	1.192
		1.201
1999	0.800	1.210
		1.250
1997	1.160	1.289
		1.301
1998	1.270	1.313

Step 1: Create a table of candidate years, indices, and cutoff values

In this case, I planned to use “winter” indices to guide selection

Step 2: For each year in historical series, select the best candidate year

ModelYr	YrSum	EndFlag	ActWntr		UseYr	Sumrlndx	WntrIndx
1911	492693	1	1.06259		2000	0.519666	1.064971
1912	500364	1	1.079134		2000	0.519666	1.064971
1913	521396	1	1.124494		1995	1.425791	1.149788
1914	459825	1	0.991704		2001	0.722998	0.976409
1915	509518	1	1.098877		2000	0.519666	1.064971
1916	559144	1	1.205905		1999	0.800194	1.210302
1917	551170	1	1.188708		1996	1.786185	1.192067
1918	528285	1	1.139352		1995	1.425791	1.149788
1919	534839	1	1.153487		1995	1.425791	1.149788
1920	505559	1	1.090338		2000	0.519666	1.064971
1921	506237	1	1.091801		2000	0.519666	1.064971
1922	461702	1	0.995752		2001	0.722998	0.976409
1923	445574	1	0.960969		2001	0.722998	0.976409
1924	487635	1	1.051682		2000	0.519666	1.064971
1925	484212	1	1.044299		2000	0.519666	1.064971
1926	528888	1	1.140652		1995	1.425791	1.149788
1927	494068	1	1.065556		2000	0.519666	1.064971
1928	483776	1	1.043359		2000	0.519666	1.064971
1929	457096	1	0.985818		2001	0.722998	0.976409
1930	392086	1	0.845611		1992	1.060596	0.862402
1931	412768	1	0.890216		1994	1.146259	0.881954
1932	381323	1	0.822399		1992	1.060596	0.862402
1933	401354	1	0.8656		1992	1.060596	0.862402
1934	371950	1	0.802184		1992	1.060596	0.862402
1935	373975	1	0.806551		1992	1.060596	0.862402
1936	404983	1	0.873426		1994	1.146259	0.881954
1937	437522	1	0.943603		2001	0.722998	0.976409
1938	405731	1	0.87504		1994	1.146259	0.881954
1939	412872	1	0.890441		1994	1.146259	0.881954
1940	430065	1	0.927521		1993	0.615068	0.91041
1941	403757	1	0.870782		1992	1.060596	0.862402

Step 3: Add years as needed to get both indices near 1.0

2004	439376.81	1	0.947603		2001	0.722998	0.976409
2005	456467.15	1	0.984462		2001	0.722998	0.976409
2006	456814.63	1	0.985212		2001	0.722998	0.976409
2007					1996	1.786185	1.192067
2008					1996	1.786185	1.192067
2009					1996	1.786185	1.192067
2010					1996	1.786185	1.192067
2011					1996	1.786185	1.192067
2012					1996	1.786185	1.192067
2013					1996	1.786185	1.192067
2014					1996	1.786185	1.192067
2015					1996	1.786185	1.192067
2016					1996	1.786185	1.192067
2017					1996	1.786185	1.192067
2018					1996	1.786185	1.192067
2019					1996	1.786185	1.192067
2020					1994	1.146	0.882
2021					1994	1.146	0.882
2022					1994	1.146	0.882
2023					1994	1.146	0.882
2024					1994	1.146	0.882
2025					1994	1.146	0.882
2026					1994	1.146	0.882
2027					1994	1.146	0.882
2028					1994	1.146	0.882
2029					1994	1.146	0.882
2030					1994	1.146	0.882
2031					1994	1.146	0.882
2032					1994	1.146	0.882

These were added to bring up both indices

These were added to bring “summer” up even more but keep “winter” ¹¹ moderated

This process was repeated based on the “summer” index, then a combination was put together weighting each selection equally.

Microsoft Excel - Sol

File Edit View Insert

Font: Arial Size: 10

Orientation: 75% Alignment: Center

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Number Format: General

Cells: A1:P1000

Range: P6

Formula Bar: P6

Table Data:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Action Levels		F92	F93	F94	F95	F96	F97	F98	F99	F00	F01				
2	Adjustable (pink)		0.1826462	0.1289748	0.1135502	0.072847	0.0693054	0.05	0.05	0.05	0.1329814	0.05				
3	Data (blue)															
4	Desired Sumr Freq		0.212	0.106	0.068	0.061	0.015	0.068	0.136	0.114	0.076	0.114				
5	Desired Wntr Freq		0.08	0.165	0.08	0.069	0.069	0.032	0.032	0.032	0.277	0.165				
6																
7	Summer Index		1.06	0.62	1.15	1.43	1.79	1.16	1.27	0.8	0.52	0.72				
8	Winter Index		0.86	0.91	0.88	1.15	1.19	1.29	1.31	1.21	1.06	0.98				
9																
10	Constraints (yellow)															
11																
12	Each year >= values in column M															
13			1	0	0	0										
14			0	1	0	0										
15			0	0	1	0										
16			0	0	0	1										
17			0	0	0	0										
18			0	0	0	0										
19			0	0	0	0										
20			0	0	0	0										
21			0	0	0	0										
22			0	0	0	0										
23			1	1	1	1										
24																
25																
26	Objective:	Weight x SSE (mean summer index - 1)														
27		Weight x SSE (mean winter index - 1)														
28		Weight x SSE (mean summer - mean winter)														

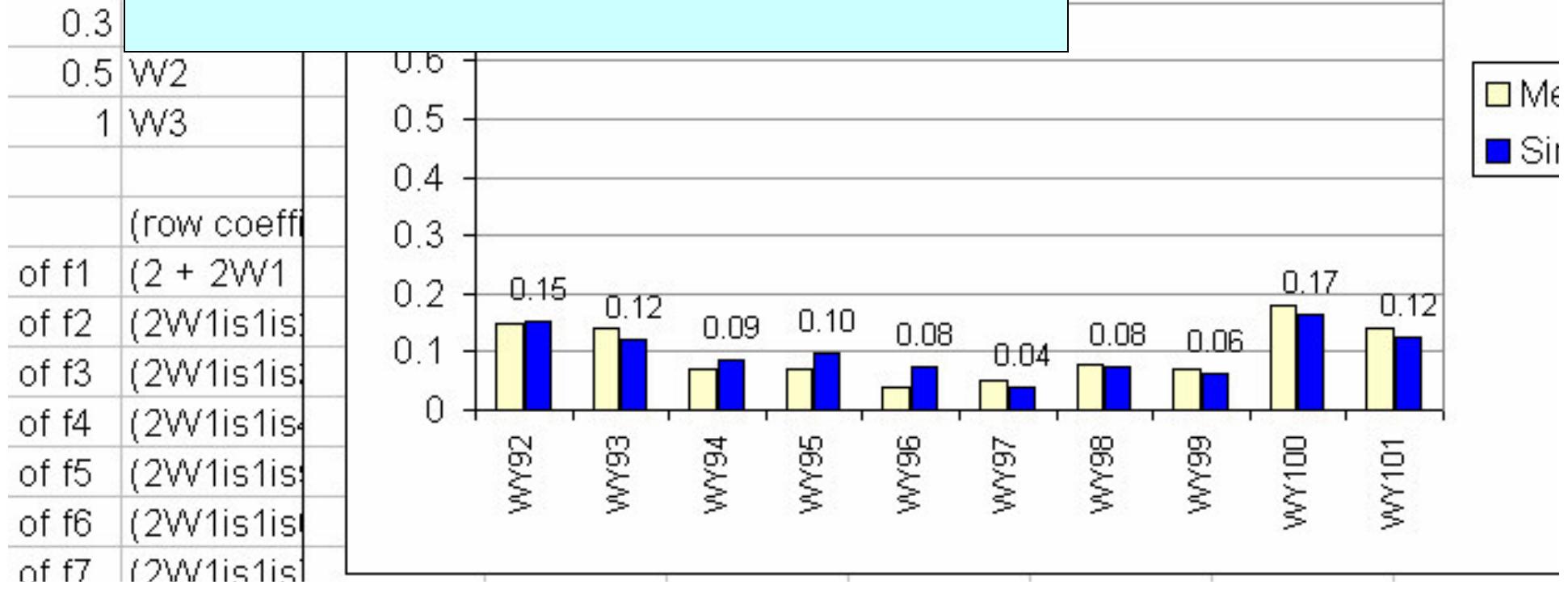
Sheet1 / Sheet2 / Sheet3

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Other attempts were made using the Excel solver

It turned out to be somewhat disappointing but I found one combination of weights and constraints that looks pretty decent.

I also built a least-squares optimizer but it didn't work any better than the Excel solver. And I haven't fully checked the spreadsheet for errors, so I didn't include its results in the pool.



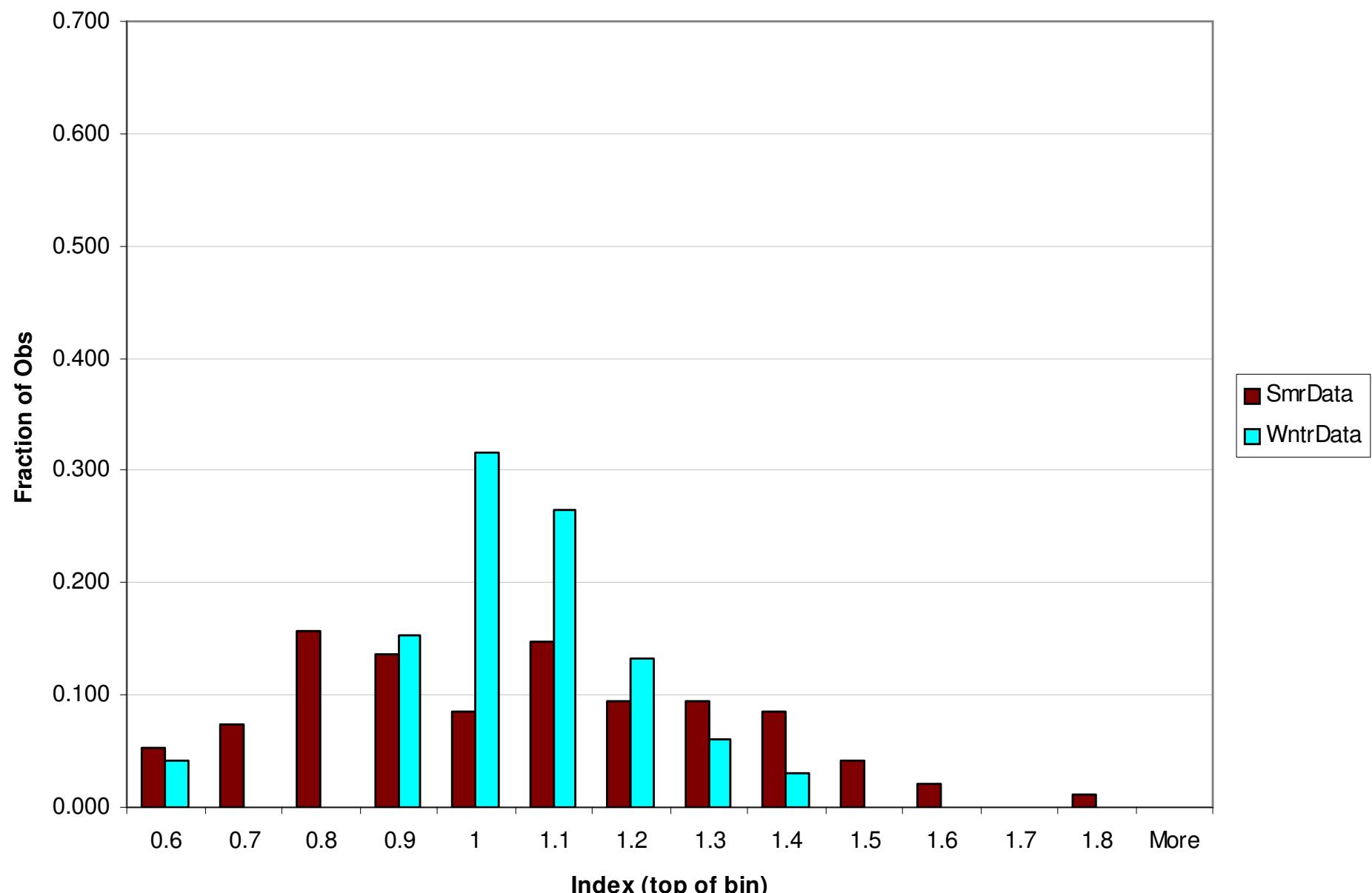
Two groups rejected

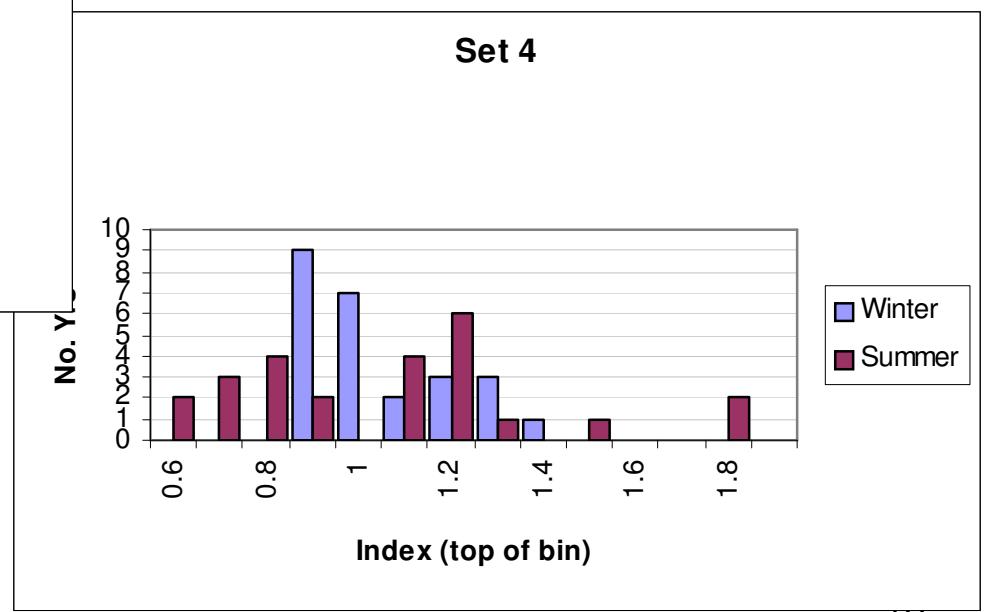
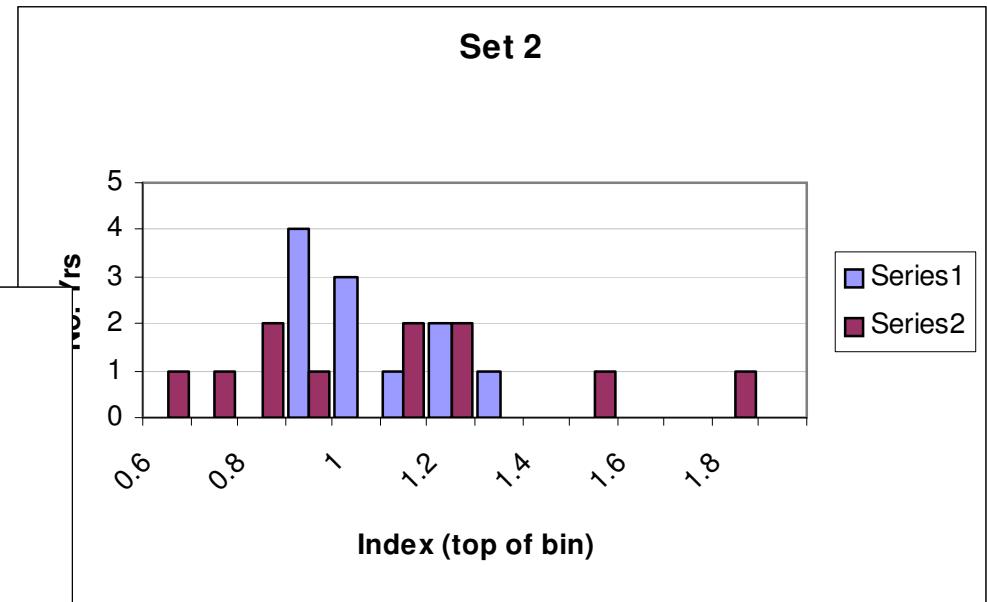
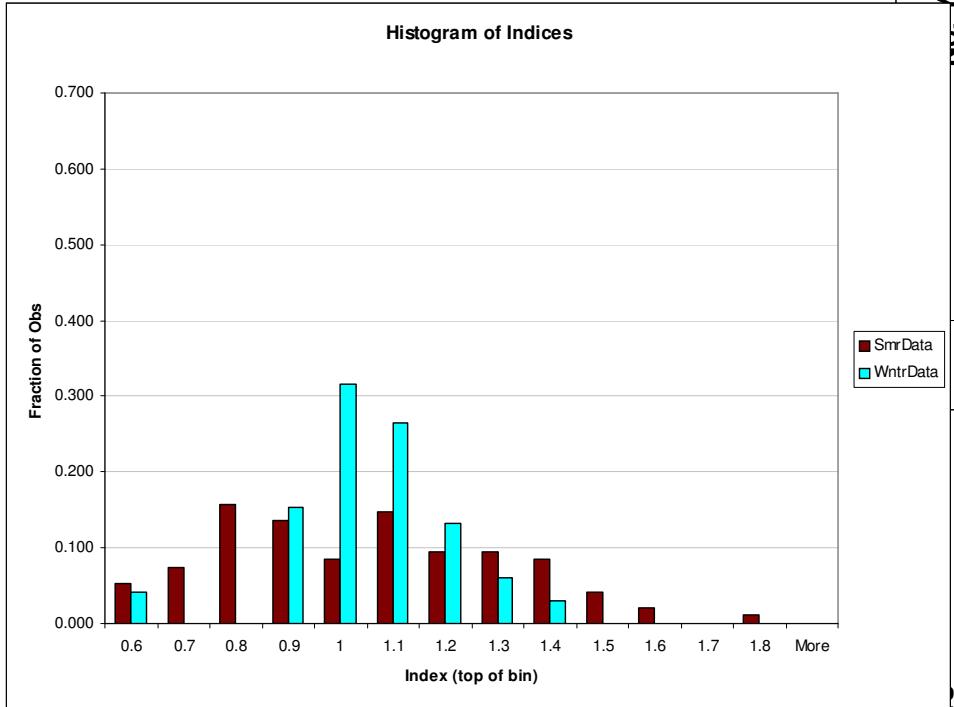
- Set 1: wrong average indices (1.09, 1.05)
- Set 3: individual years over-represented, many years missing

Characteristics

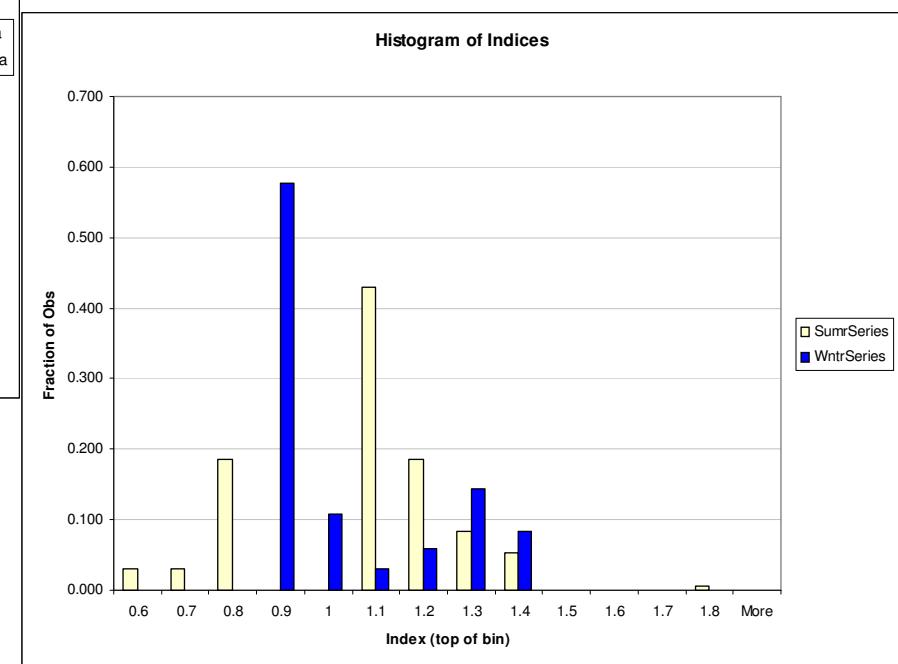
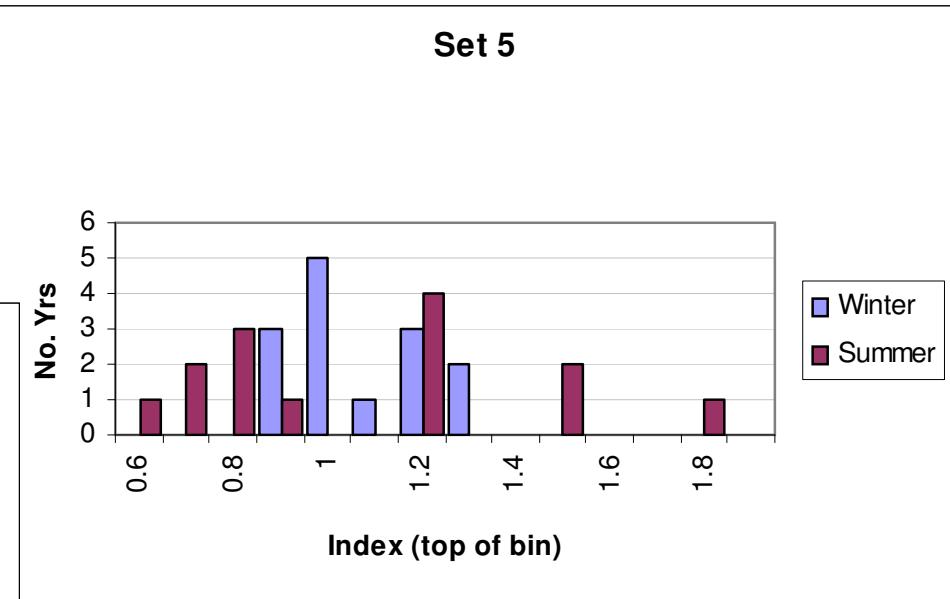
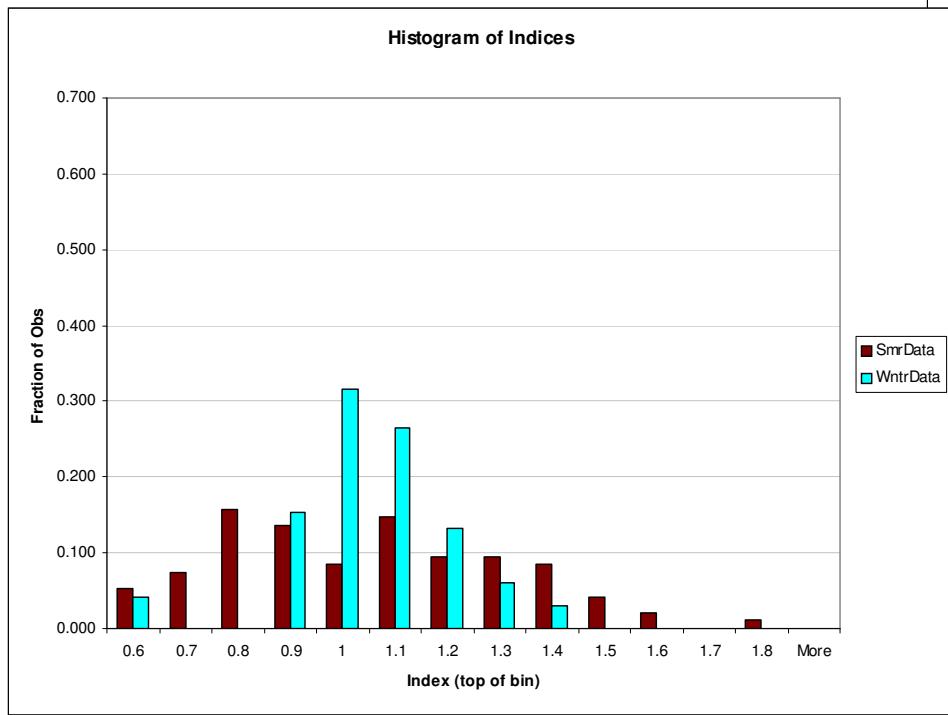
1. Index Histograms

Histogram of Indices (Full Historical Series)

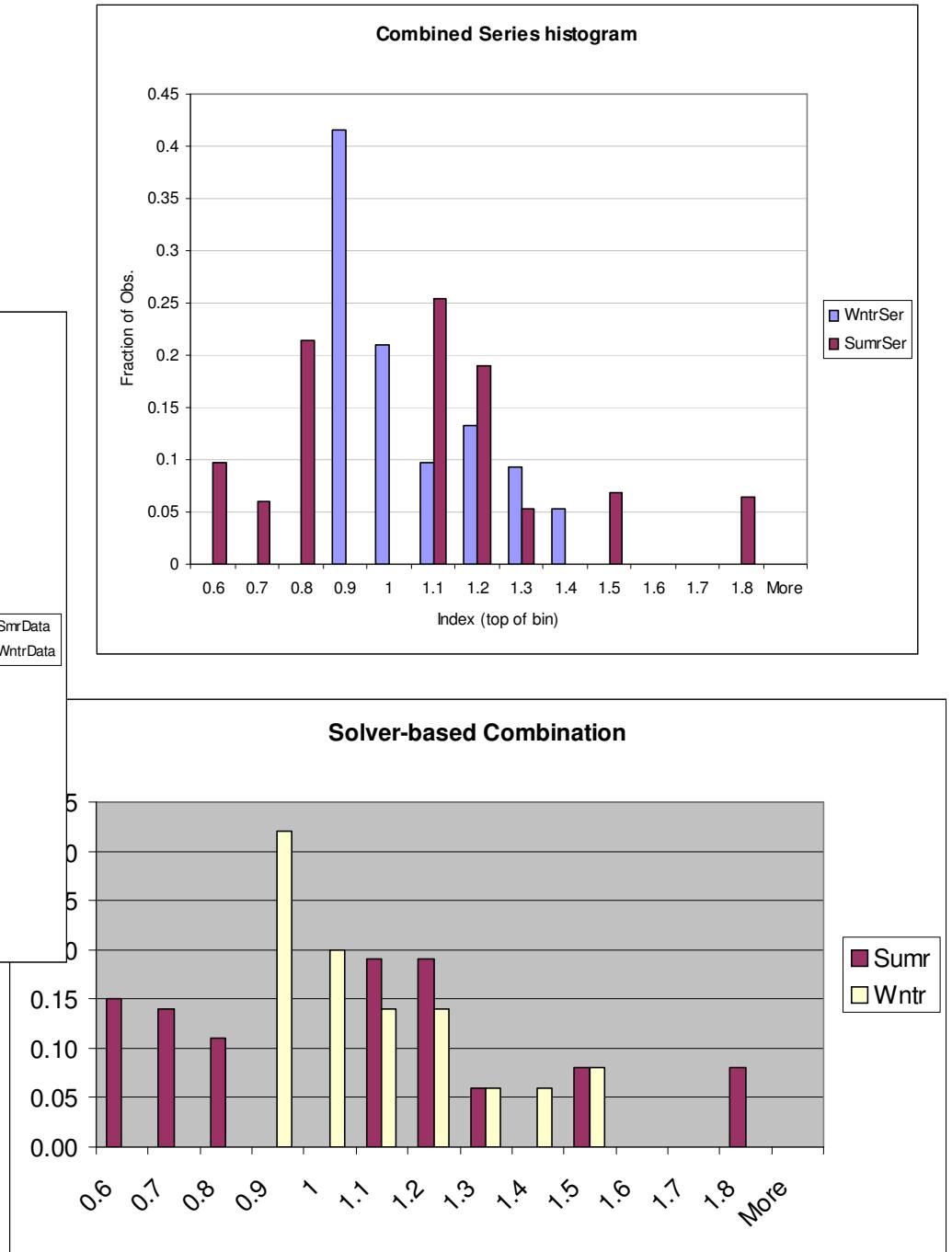
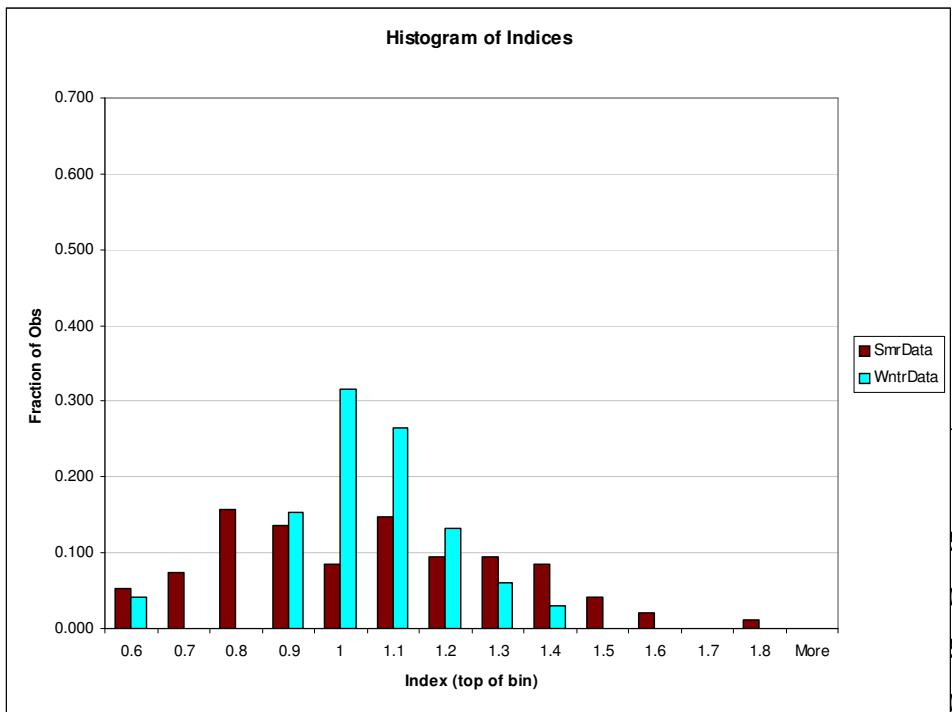




Set 5

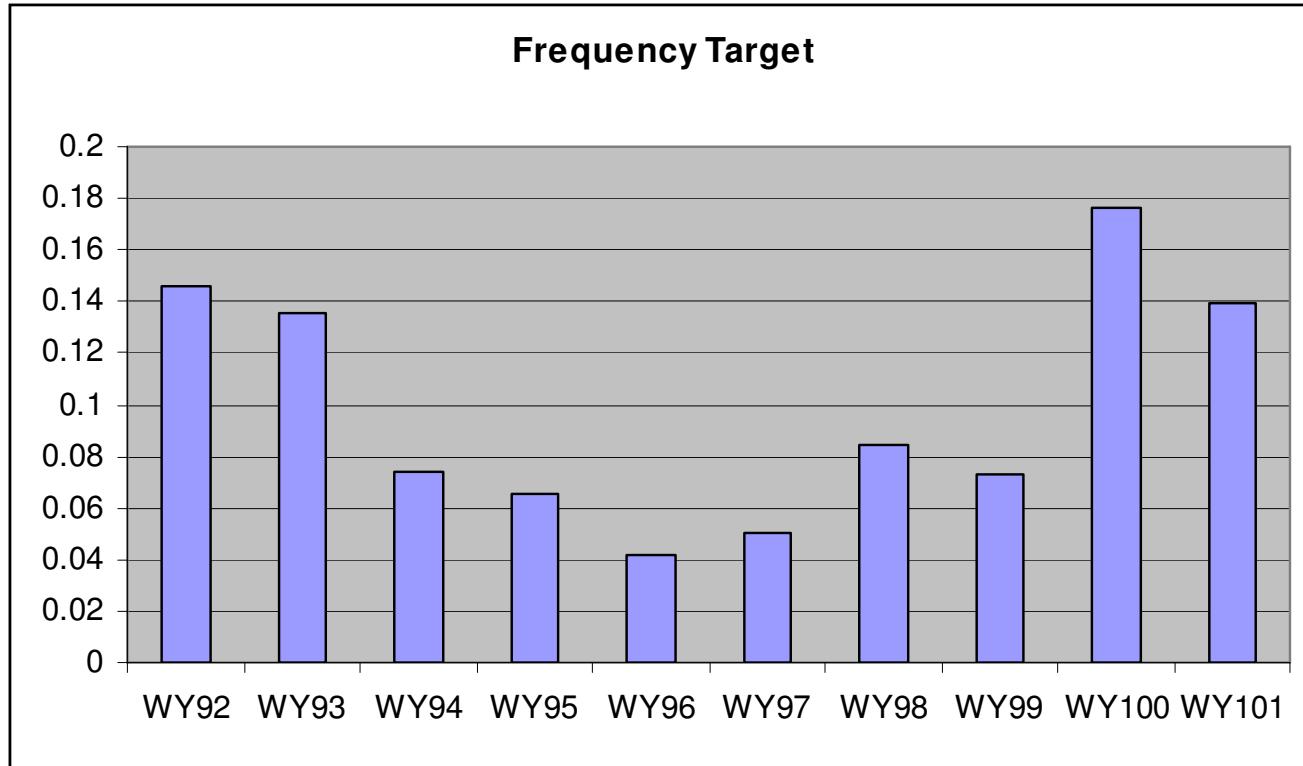


(summer from summer, winter
from winter)

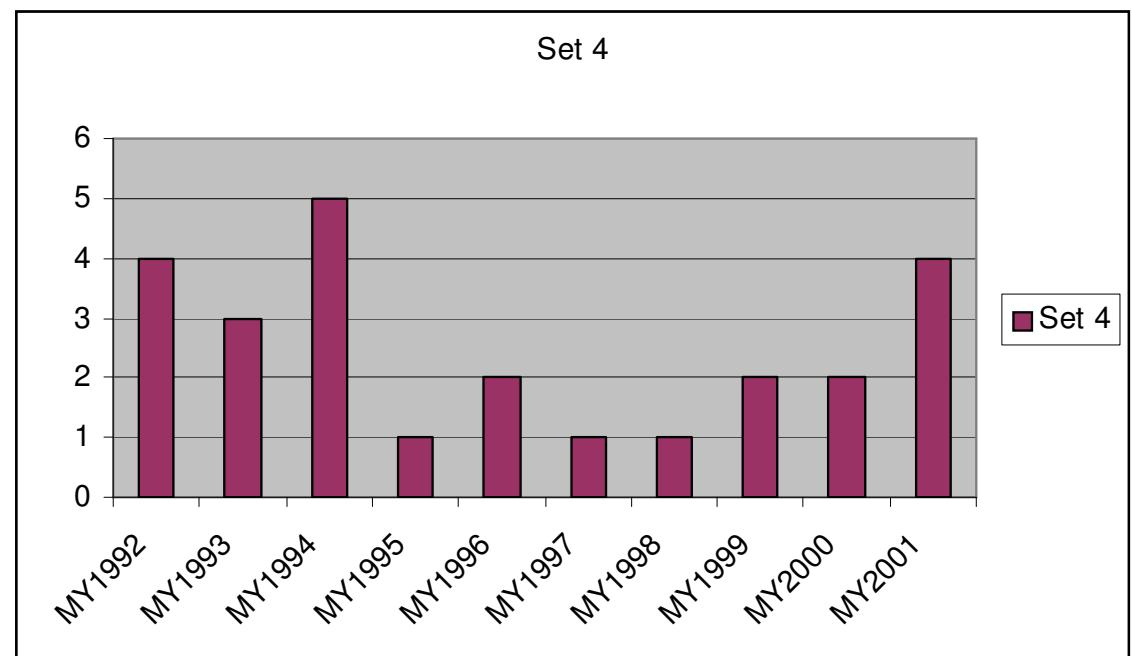
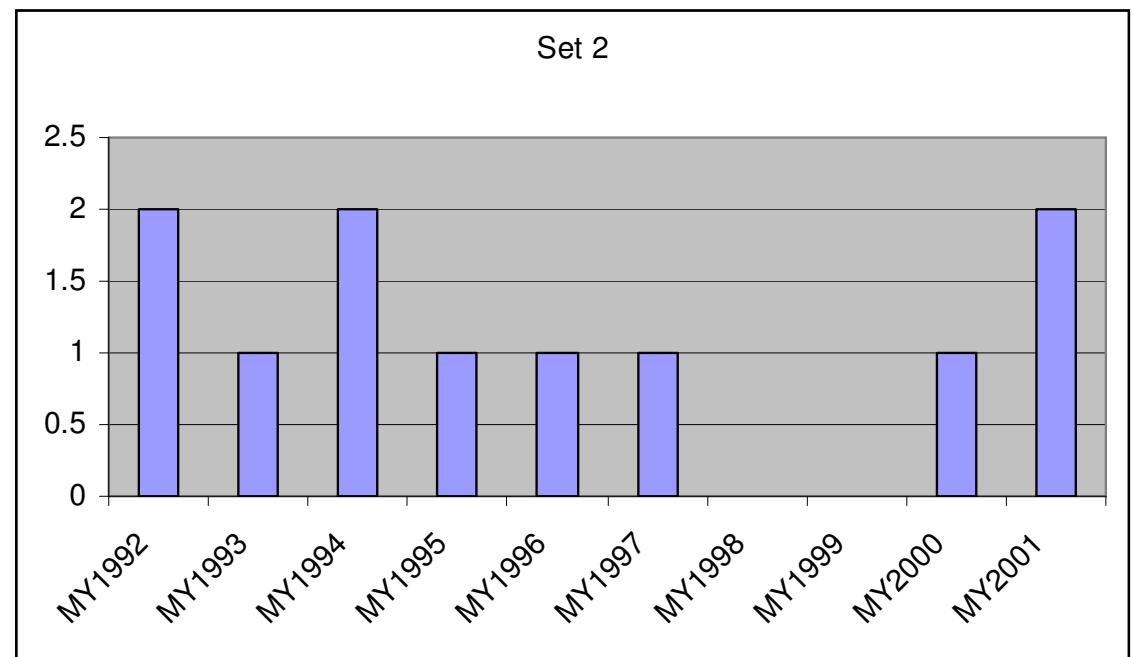
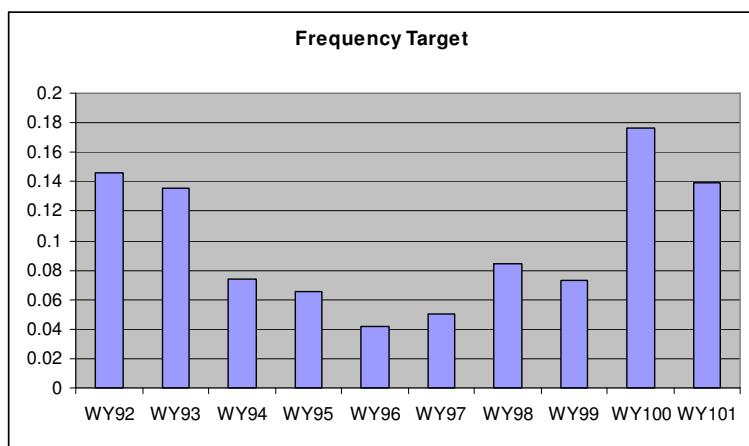


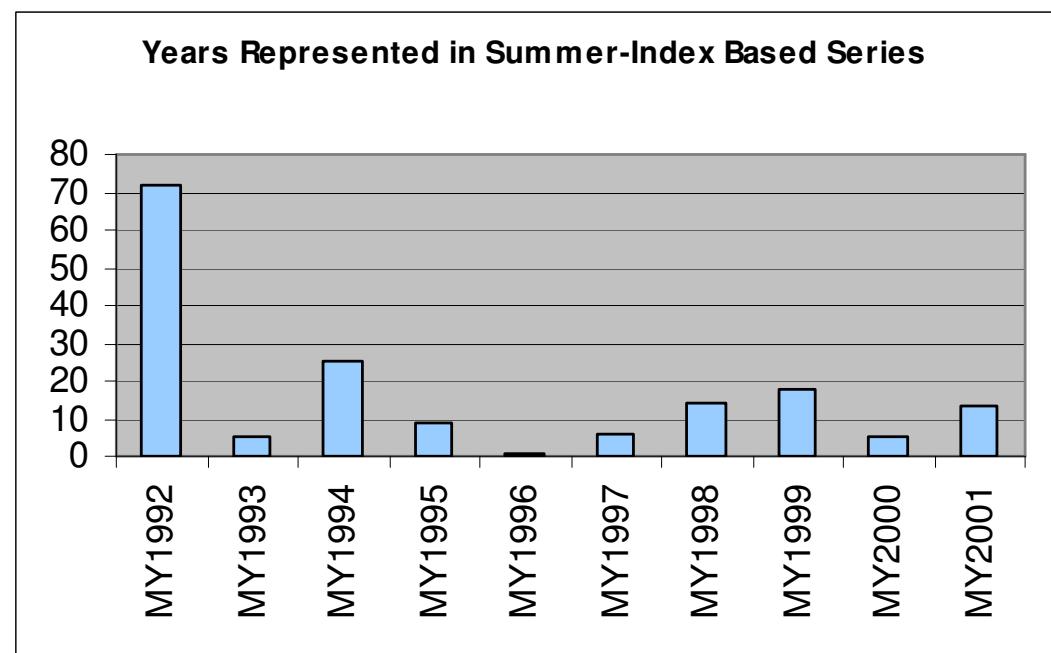
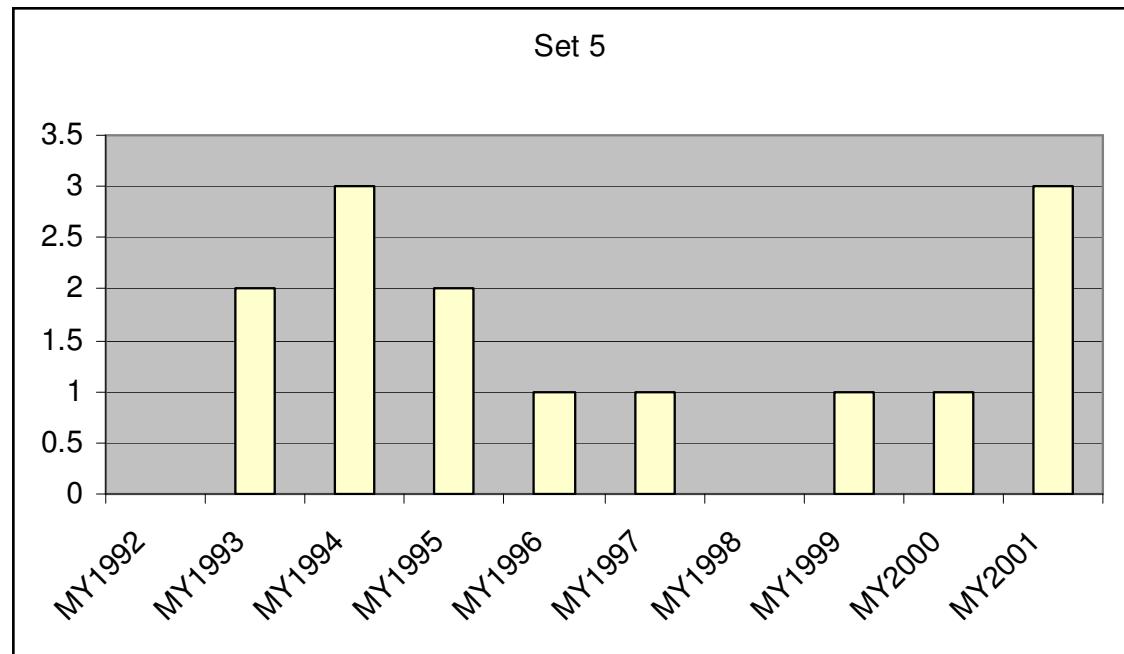
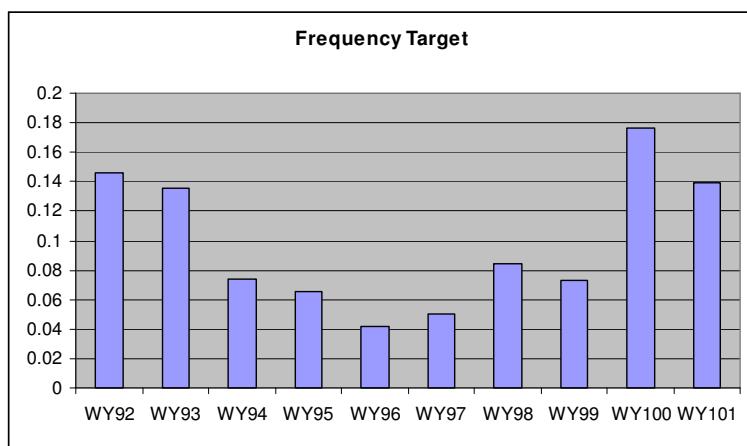
Characteristics

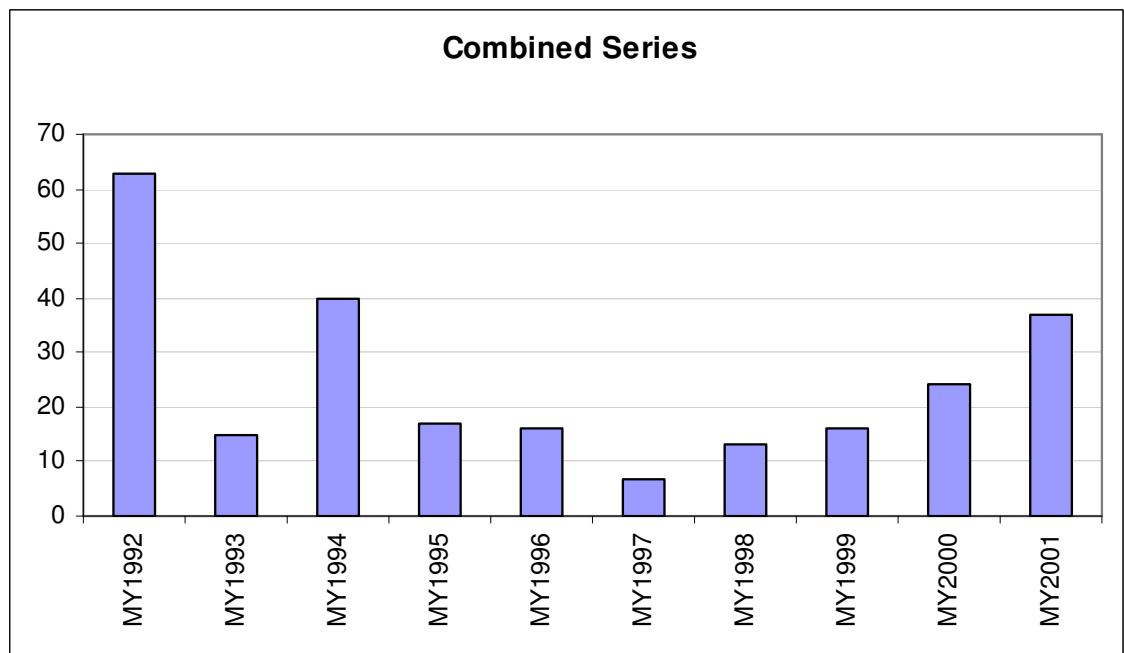
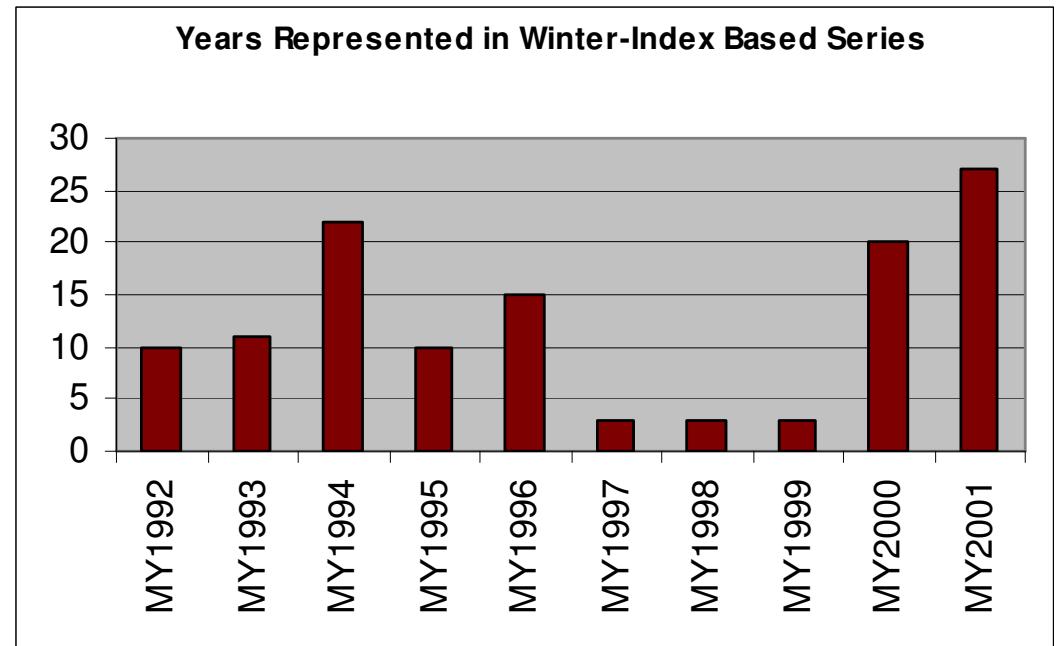
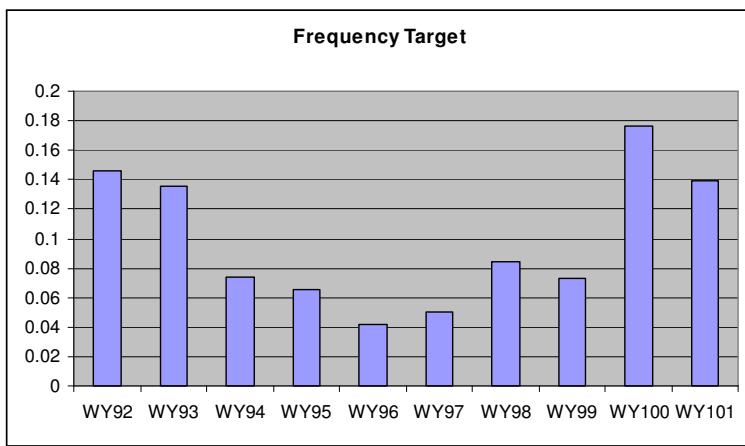
2. Representation by Year

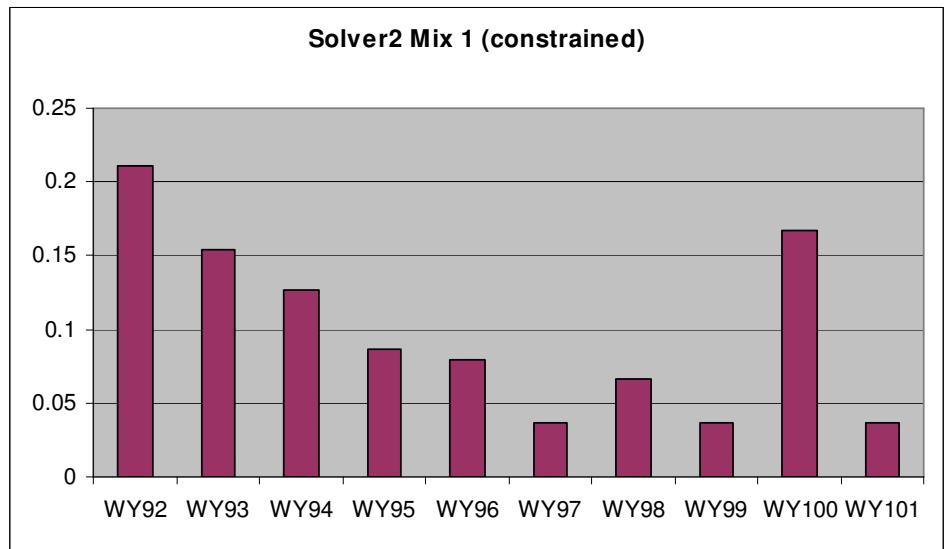
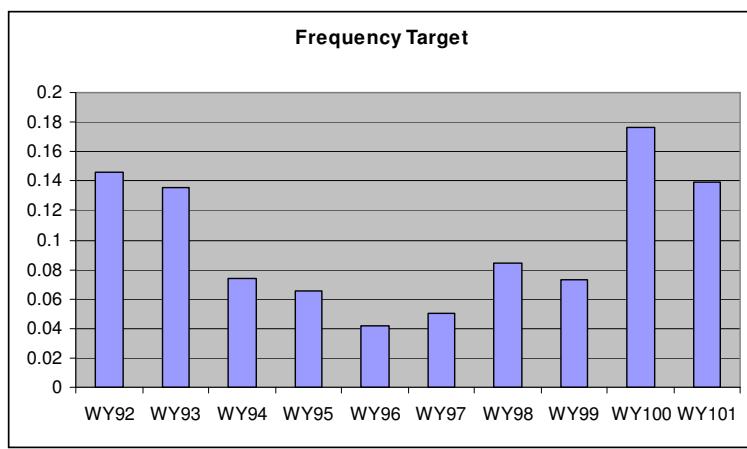


These targets were derived by comparing the histogram bins of the target years with the histogram bins of the historical series, then averaging the “summer” and “winter” scores. This looks odd because if two years fell in the same bin, that bin’s expected frequency was split between those two.









How much difference does it make in the well term?

¡Cuidado!

We can't head down that slippery slope...

because we
don't have the
luxury of knowing
what the answer
ought to be.



We need to objectively score the candidates

- Indices close to 1.0 and not biased
- Frequency distribution of indices is like the historical data
- We don't leave out years in the pool and we don't lean too heavily on individual pool years

Bryce's Scorecard

Series	WntrIdx	Smrlndx	IdxHstgr	UnderRep	OverRep	Score
2	0.997	1.001	5	X		2
4	1.013	0.988	5			1
5	1.032	0.997	4			-1
Summer	0.989	1.035	3	X	X	-3
Winter	1.020	0.994	3	X		-1
Combined	1.004	1.014	5			1
Solver	1.017	0.999	4			1

(all factors equally weighted)

Alternate Scorecards

Series	WntrIdx	SmrlIdx	IdxHstgrn	UnderRep	OverRep	Score
2	0.997	1.001	5	X		1
4	1.013	0.988	5			1
5	1.032	0.997	4			-0.5
Summer	0.989	1.035	3	X	X	-2.5
Winter	1.020	0.994	3	X		-1
Combined	1.004	1.014	5			1
Solver	1.017	0.999	4			0.5

Series	WntrIdx	SmrlIdx	IdxHstgrn	UnderRep	OverRep	Score
2	0.997	1.001	5	X		0
4	1.013	0.988	5			1
5	1.032	0.997	4			0
Summer	0.989	1.035	3	X	X	-2
Winter	1.020	0.994	3	X		-1
Combined	1.004	1.014	5			1
Solver	1.017	0.999	4			0

Possibilities

- “Solver,” “Set 2” and “Set 4”?
 - 2 and 4 have best scores
 - Solver is most objective?
 - Solver’s scores aren’t bad
 - Solver’s indices are nominal unbiased
- “Set 2,” “Set 4” and “Combined”
 - Combined has better histogram
- “Set 4,” “Combined,” “Solver”
 - Set 2 omits a couple of pool years

End